1899

Ticks and Texas fever

Harcourt Alexander Morgan

SECOND SERIES, NO. 56.

BULLETIN

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AGRICULTURAL EXPERIMENT STATION

—OF THE—

Louisiana State University and A. & M. College,

WM. C. STUBBS, PH. D., Director and State Chemist.

"TICKS AND TEXAS FEVER,"

BY H. A. MORGAN.

ISSUED BY THE BUREAU OF AGRICULTURE AND IMMIGRATION,
LEON JASTREMSKI, COMMISSIONER.

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Baton Rouge, Louisiana.

Gen. Leon Jastremski, Commissioner of Agriculture and Immigration, Baton Rouge, La.:

MY DEAR SIR—I hand you herewith bulletin on "Ticks and Texas Fever," prepared by Prof. H. A. Morgan, Entomologist of the State Experiment Station. Since this Texas fever has been a barrier to the importation of Northern cattle [illegible] ticks which are the di-

ERRATA.

Unipuncta occurring in this bulletin should read "Unipunctata."

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MY DEAR SIR—I hand you herewith bulletin on "Ticks and Texas Fever," prepared by Prof. H. A. Morgan, Entomologist of the State Experiment Station. Since this Texas fever has been a barrier to the importation of Northern cattle for the purposes of breeding, and the ticks, which are the direct cause of the former, have prevented us from shipping Southern cattle to Northern States without thoroughly cleansing them, and since the raising of cattle throughout the State of Louisiana is deemed of special interest to all of our farmers and planters, this bulletin has been prepared with the view of throwing all the light possible upon these two subjects, Ticks and Texas Fever, and I herewith transmit it to you and ask that it be published as Bulletin No. 56.

Very respectfully submitted,

WM. C. STUBBS, Director.

TICKS AND TEXAS FEVER.

The publication of Bulletin 51 on "Cattle Ticks and Texas Fever," and its distribution among the farmers and stock-breeders of the State has excited an interest in the matter of cattle ticks which heretofore has not been manifested. The fact that the danger of losing imported cattle from Texas fever might be obviated, suggested to the minds of many, fresh trials of blooded stock, and in several parts of the State, a few head of well bred cattle, particularly those of the beef types, have been introduced. With the introduction of high priced animals has come a desire for more information on Texas fever and the conveyor of the Texas fever germ, the cattle tick (*Boophilus bovis*), and the possibility of eradicating it from our pastures. In Bulletin 51, one of the ways suggested of eradicating the cattle tick, was to starve it out by a systematic rotation which changed yearly the pastures of cattle. It was found that this tick could not survive longer than seven or eight months unless its hosts, horses and cattle, were allowed upon the pasture. To this suggestion many took objection, for, as one gentleman stated, he had not had cattle or horses upon a piece of woodland for twenty-five years, and yet a person would become covered with seed ticks by walking over this land any time during the summer months. This was easily explained in that other species of ticks (those infesting squirrels, rabbits, minks, deer, dogs, etc.) have also their seed ticks, and possibly it was these which infested his woodland. It is extremely doubtful if the seed ticks of the true cattle tick (*Boophilus bovis*) can be found among them. The question arises then: will such seed ticks give susceptible cattle Texas fever; if not, how may one determine when he has the seed ticks of the cattle tick in his pasture or those of other species? To answer satisfactorily these questions experiments were conducted with the lone star tick (*Amblyomma unipunctia*) and the wood or dog tick (*Dermacentor americanus*). These species are not uncommon par-

asites of cattle, and maturing also upon deer, dogs and other mammals, are liable to infect any pasture. Should they, too, convey the Texas fever germ (which, fortunately, they do not), the solution of the problem of disinfecting pastures and thereby removing the danger of fever, would become almost impossible.

Some of the common forms of seed ticks occurring in open and woodland pastures are illustrated on plates I, III, V and VIII. A study of the general shape and of the mouth parts of these seed ticks will reveal differences easily remembered. As the general differences may be determined with a pocket lense, it is therefore possible, yea, important, that every stock breeder should know seed ticks which will transmit Texas fever from those which will not.

The seed ticks which are liable to infest cattle are those of the cattle tick (*Boophilus bovis* Riley), the lone star tick (*Amblyomma unipuncta* Pack); the wood or dog tick (*Dermacentor americanus* Linn) and those of a smaller species (*Ixodes ricinus* Linn).

THE CATTLE TICK (*Boophilus bovis* Riley).

For a discussion of the cattle tick reference is made to Bulletin 51, second series, of the Louisiana State Experiment Stations. The point, however, that the cattle tick is agamic, *i. e.*, able to produce fertile eggs without the intervention of the male seems to have been proven by last season's observations. On July 2nd a susceptible animal was placed in a pasture, which the season previous was infested with cattle ticks. The chief object of the experiment was to determine if the ticks could be starved out by July 1st. No ticks were found upon the animal until August 13th, when four specimens were discovered in the second stage of their development—just previous to their second molting. Three of these specimens were found on the anterior portion of the animal, and one on the posterior. As the latter proved to be a female (after the second molt, which took place on August 15th) an excellent opportunity was afforded to determine if such a thing as an agamous condition existed. Observations were made at least twice a day, and at no time was a male found attached to or near

this female, while the female on the anterior portion of the animal was associated with a male during the entire third stage. As copulation does not take place previous to the second molt, but during that molt, and during all of the parasitic period of stage III, there can hardly be any doubt of the accuracy of the observation. This female was removed on August 17th (before complete engorgement had taken place), deposited eggs on August 20th and the three days following, and on September 10th the eggs began hatching.

This observation is not of so much importance in connection with the economy of the cattle tick, as this species remains attached to its host from the seed tick stage on, and has ample opportunity for sexual contact, but, as might be expected, in the case of the lone star tick, and the wood or dog tick, where they drop at different stages, an agamic female would assure the perpetuation of the species, when it so happened that only one female was fortunate enough to find a host.

From observations made last year we are more and more convinced of the efficacy of the *starving out* method of ridding pastures of the cattle tick. The suggestion made in Bulletin 51 of annually rotating pastures together with the oiling and dipping of stock, when placed in disinfected fields, is thoroughly proven, not only from the observations upon the life history of the cattle tick, but by actual practice.

LIFE HISTORY OF THE LONE STAR TICK.
(*Amblyomma unipuncta* Pack.)

As a parasite of cattle, this species is, in importance, next to the cattle tick. It may be reared exclusively upon cattle, but it is frequently found upon deer, dogs and other mammals. March and April are the months it is found most troublesome to cattle in this State, in fact stage III (before engorgement of the female) is the important parasite of stock during early spring. The male and female (see plate III, figs. 3 and 4) are the ticks which annoy moss gatherers, who collect this product during March and April. The ticks find moss which has fallen to the ground with broken limbs a suitable shelter in cold weather and a favorable place to gain access to

EXPLANATION OF PLATES—I to IV.

PLATE I.

CATTLE TICK (*Boophilus bovis* Riley).

Fig. 1. Seed tick.
2. Mouth parts of seed tick.
3. Full grown male.
4. Female just after the second molt, and before engorgement.
5. Mouth parts of mature male (ventral view).
6. Mouth parts of mature female (ventral view).
7. Mouth parts of mature female (dorsal view, showing papillated spots).

PLATE II.

CATTLE TICK (*Boophilus bovis* Riley).

Fig. 1. Female fully engorged (small one shows natural size).
2. Mandible of the mature female.
3. Mandible of the mature male.
4. Tarsus of the mature male.
5. Tarsus of the mature female.
6. Ventral view of a portion of the female body, showing coxæ.
7. Spiracle of mature female.
8. Ventral view of a portion of the male body, showing coxæ.

PLATE III.

LONE STAR TICK (*Amblyomma unipuncta* Pack).

Fig. 1. Seed tick.
2. Mouth parts of seed tick.
3. Full grown male.
4. Female just after second molt, and before engorgement.
5. Mouth parts of mature male (ventral view).
6. Mouth parts of mature female (ventral view).
7. Mouth parts of mature female (dorsal view, showing papillated spots).

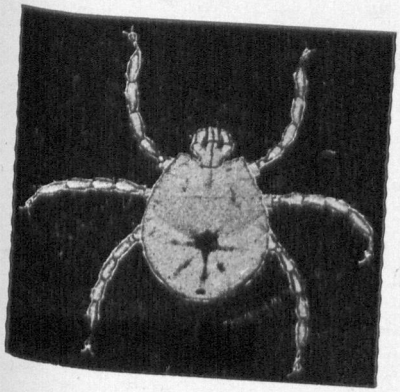
PLATE IV.

LONE STAR TICK (*Amblyomma unipuncta* Pack).

Fig. 1. Fully engorged female.
2. Engorged tick, just before second molt.
3. Tarsus of mature female.
4. Tarsus of mature male (engraver omitted to show segmentation of tarsus; it appears about as in the female).
5. Coxæ of female.
6. Coxæ of male.
7. Mandible of female.
8. Mandible of male.
9. Tarsus of tick, just previous to second molt.
10. Spiracle of mature female.

NOTE.—All drawings much enlarged; natural size of many indicated by line to the right of specimen.

PLATE I.



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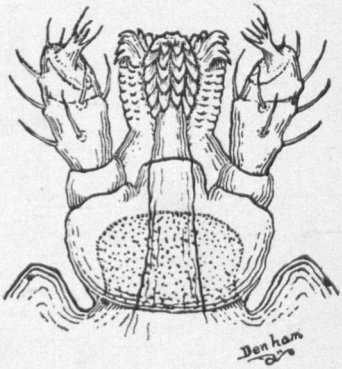

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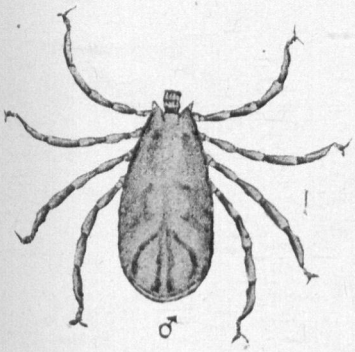

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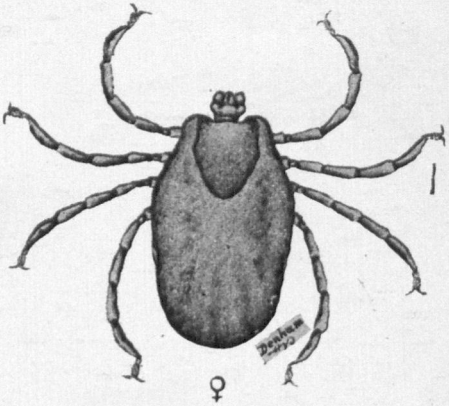

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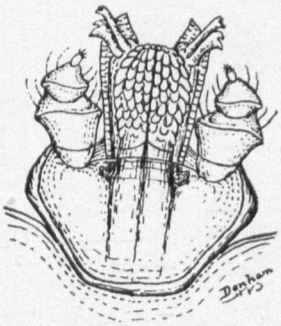

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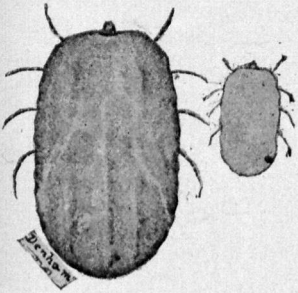
PLATE II.



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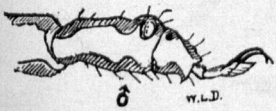

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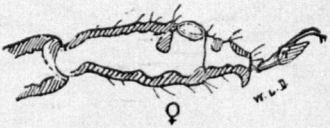

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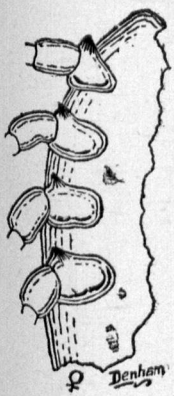

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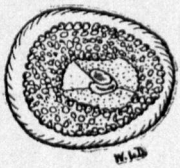

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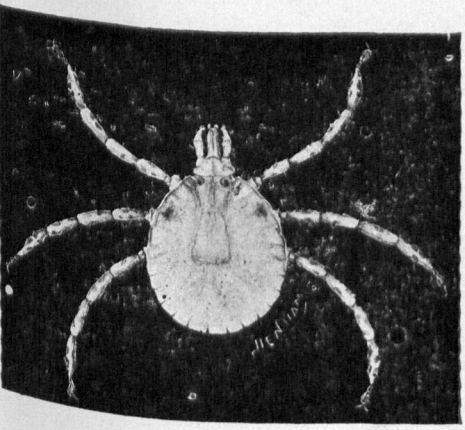
PLATE III.



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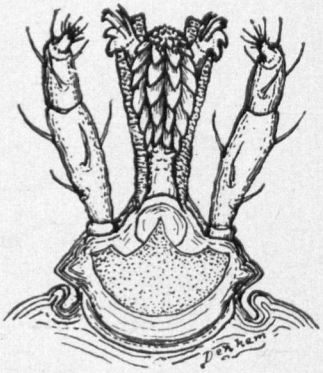

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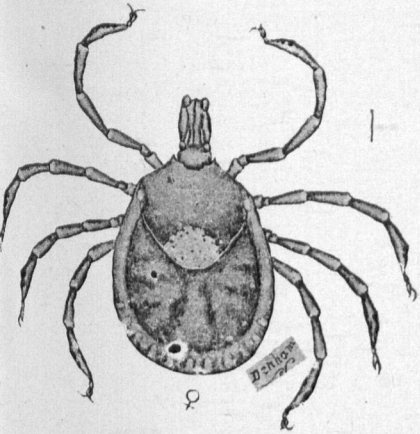

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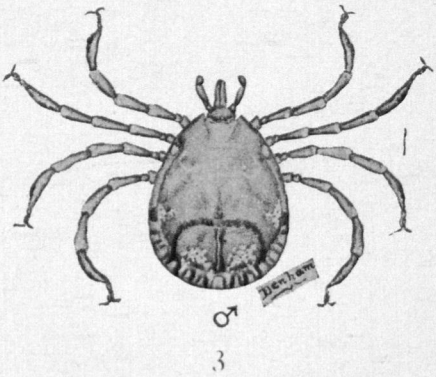

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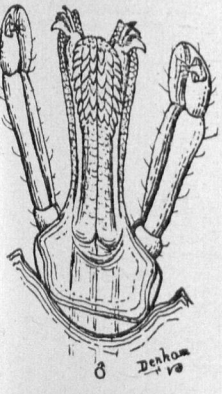

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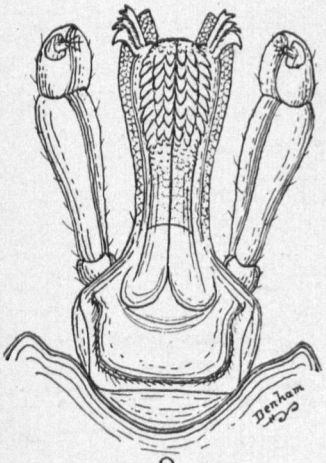


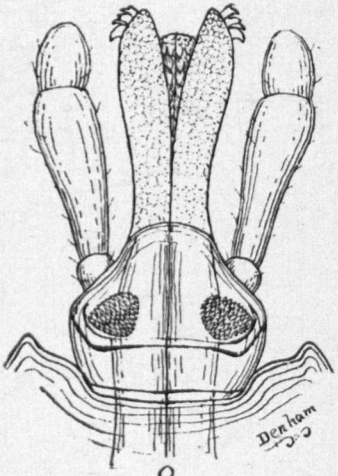
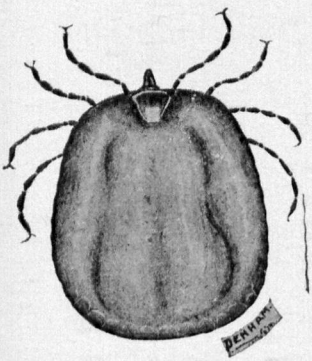


PLATE IV.



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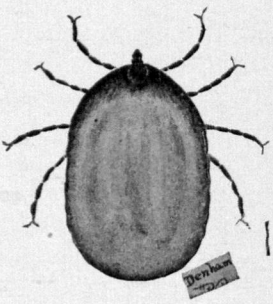

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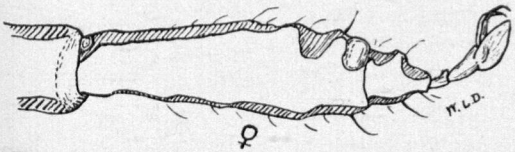

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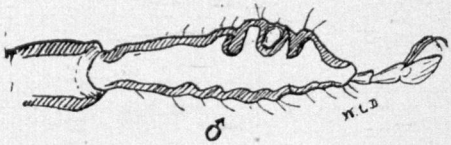

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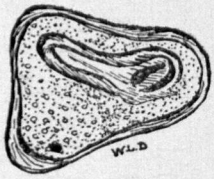

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animals that seek the more woodland portions of their pastures for food in early spring.

The eggs of several females were counted, and the number ranged from 3230 of a specimen collected from a deer to 6519 of a female collected from the ear of a dog.

A fully engorged female collected March 20, 1898, began depositing eggs April 24, more than three weeks later, and by May 10 had deposited 5297 eggs; on May 18th, 1136 additional eggs were counted, and on May 27th 86 more were found, making a total of 6519 eggs. Egg laying period from March 30th to May 27th, nearly two months. The seed ticks began to appear on June 4th and continued appearing throughout the month. In this condition they appear to possess the same power as those of the cattle tick, of existing a long time without food, for specimens which hatched on June 4th were kept until July 2nd before being placed upon a host.

The seed ticks of the lone star species are very active and when placed upon cattle begin at once to attach themselves. By July 6th and 7th the specimens which were placed on animal July 2nd, were well distended, previous to the first molt, and by July 9th all had disappeared—had dropped off. A couple of the specimens were, however, collected previous to first molt, and were placed in a small box and carried to the laboratory to determine exact period of molting. The specimens were no doubt injured in being removed from their host, as this frequently occurs with larger and older ticks, and died in a few hours. None of this infestion were raised.

On June 1st a fully engorged female was collected from a cow, and on June 5th began laying eggs. As will be seen, the period of time consumed between full engorgement and oviposition is largely influenced by temperature. Eggs began hatching July 4th, and the seed ticks placed upon animal July 16th. On July 20th the ticks were much distended preparatory to first molt, but on the 20th and 21st began disappearing, leaving only a few specimens to molt upon the animal, and these later disappeared, July 26th, just previous to the second molt.

A second application of seed ticks of the same batch (those which hatched on July 4th) was made on July 25th,

with the result that but a very few specimens reached the state of engorgement previous to the second molt.

A third effort was made to rear the lone star tick upon cattle, when great numbers of seed ticks, which hatched on August 4th, were placed upon cattle on August 9th. By August 12th distention of the specimens was apparent, and on August 19th more than a dozen specimens were found, between the first and second molts. On August 22nd a few specimens were collected just prior to the second molt (as was supposed) and were placed in a small box to determine the molting period. By August 24th all of the ticks had disappeared from the cattle, indicating again that the lone star tick does not molt the second time upon cattle. Careful examination was made from day to day, of the specimens placed in the small box, and up to September 7th, when they molted, they remained quiescent with legs drawn close to the body. There can be but little doubt that these periods of perfect quiescence just previous to molting are important in tiding the species over unfavorable conditions.

On April 19th, 1899, specimens of the lone star tick were collected just previous to the second molt and placed in cages. It was not until May 9th, 1899, that molting took place—a period of nearly six weeks. As this quiescence occurred during comparatively warm weather, it seems to emphasize the importance of this period as a hibernating one. This fact is borne out by the one that it is the condition of the lone star tick, just after the second molt, that is so abundant in early spring.

The time required by females to fully engorge depends upon temperature. Specimens placed upon animals, just after the second molt, March 23rd, were fully engorged April 3rd. Others put on animals April 1st were engorged April 7th. A point of considerable importance in the economy of this tick is that after molting it will exist many days, even months, without food. Specimens under observation molted the second time on September 7th and remained alive in a closed box until October 23rd. The dormancy previous to molting, the wonderful fasting powers after molting, and the prolonged periods of oviposition, of hatching and of growth during cold

weather, make it possible for this species to perpetuate itself with but one brood per year. Last year (1898) the latest application of seed ticks of this species was made in August and specimens of the III stage were collected in the same pasture during March, 1899, while at no time between these dates were fully engorged females seen upon the animal which fed in this pasture. The circumstances surrounding this observation indicate that but one brood infested this pasture during the year.

HABITS OF OTHER SPECIES OF TICKS.

THE WOOD OR DOG TICK (*Dermacentor americanus* Linn).

A female collected from the ear of a dog July 19, 1898, began depositing eggs on July 24th, and by August 9th had deposited 7378 eggs; the parent died August 18th. The eggs began hatching on August 20th, and on August 29th the seed ticks were placed upon cattle. The young are less active than those or other species, when bunched upon plants or even when placed upon cattle.

No ticks of the first infestion (August 29th) could be found upon the cattle after the second day and a second liberal application of seed ticks was made on September 5th, but the result was similar to that of the first infestion: no ticks remained upon the animals. It is very probable that this species is parasitic during its first and second stages upon other mammals, and is only parasitic upon cattle during the third (last) stage, as it is the third stage that is collected in woodland pastures, and this stage, only, that is found upon cattle. The period of time consumed by the female to fully engorge is, as in other species, dependent upon the temperature. Under ordinary summer temperature engorgement takes place in from five to eight days. See illustrations of stages of this species on plates V and VI.

Ixodes ricinus Linn.

In Europe this tick is known as the "dog tick," infesting kennels in such numbers as to become a serious pest. It is recorded by Neumann as occurring upon dogs, Wallachian sheep, Sardinian oxen, and even upon man himself. The

small mammals mentioned by Neumann are the mole, dormouse, squirrel, hare and rabbit. Prof. Osborn mentions in Bulletin 5, new series, of the Department of Agriculture, Division of Entomology, Washington, D. C., finding *Ixodes ricinus* (identified oy Dr. Marx) abundant upon the ground squirrel of the Mississippi valley. Dr. Niles, of the Virginia Experiment Station, in Bulletin No. 3, Volume VII, new series, records the occurrence of this species upon cattle.

In Louisiana (at Baton Rouge and at Calhoun) we have found specimens of *Ixodes ricinus* abundant upon the mink and upon cattle. Only those of the third stage were found on cattle, while all stages were found upon the mink. While some slight differences were at first thought to exist between those found on the mink and those on cattle, and drawings of of each were made (compare plates VII, VIII and IX), yet we believe the two forms identical.

From the fact that all stages of *Ixodes ricinus* were found upon the mink, it is supposed that this species remains upon its host during the entire period of development. We regret that we have been unable to breed this species, nor have any experiments been conducted, with the view of ascertaining whether or not it may convey the tick fever germ.

Other ticks recognized as distinct by hunters are said to occur in Louisiana, as the rabbit tick (perhaps *Rhipistoma leporis*), the deer tick (perhaps *Dermacentor occidentalis*), and the bear tick, but we have not collected specimens of these.

THE LONE STAR AND WOOD TICKS DO NOT TRANSMIT THE BOVINE FEVER GERM.

One would naturally suppose that other species of ticks would convey the bovine fever germ, since the cattle tick (*Boophilus bovis*) is such a vigorous transmitter of it, yet from an abundance of evidence gathered last year (1898) the lone star tick (*Amblyomma unipuncta*) and the wood or dog tick (*Dermacentor americanus*) do not convey this germ.

EXPERIMENTS WITH THE LONE STAR TICK.

These were begun on susceptible animals on July 2, 1898. Mature ticks were collected from three sources: From deer owned by Hon. Wm. Garig and kept in a large park about

EXPLANATION OF PLATES—V to IX.

PLATE V.

WOOD OR DOG TICK (*Dermacentor americanus* Linn).

Fig. 1. Mouth parts of the seed tick.
2. Seed tick.
3. Female just after second molt, and before engorgement.
4. Mouth parts of mature male (ventral view).
5. Full grown male.
6. Mouth parts of mature female (ventral view).

PLATE VI.

WOOD OR DOG TICK (*Dermacentor americanus* Linn).

Fig. 1. Mouth parts of the female (dorsal view showing papillated spots).
2. Fully engorged female.
3. Tarsus of the mature male.
4. Tarsus of the mature female.
5. Coxæ of the female.
6. Coxæ of the male.
7. Mandible of female.
8. Mandible of male.
9. Spiracle.

PLATE VII.

Ixodes ricinus Linn (From cattle).

Fig. 1. Fully engorged mature female.
2. Mouth parts of mature female (ventral view).
3. Mouth parts of mature female (dorsal view, showing papillated spots).
4. Tarsus of mature female.
5. Coxæ of mature female.
6. Spiracle.

PLATE VIII.

Ixodes ricinus Linn (From mink).

Fig. 1. Seed tick.
2. Mouth parts of seed tick.
3. Female, slightly engorged.
4. Mouth parts of mature female (ventral view).

PLATE IX.

Ixodes ricinus Linn (From mink).

Fig. 1. Coxæ of mature female.
2. Mandible of mature female.
3. Mouth parts of mature female (dorsal view, showing papillated spots).
4. Tarsus of mature female.
5. Spiracle.

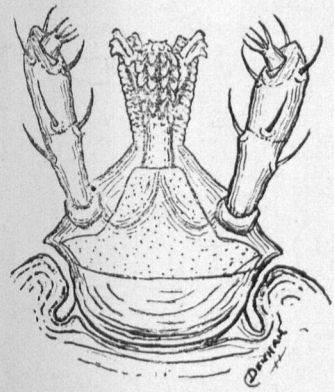
Diagramatic mouth parts of ticks.

Fig. 6. Dorsal view of mouth parts:
md mandibles.
mx maxillæ.
P palpus.
Ps papillated spots.
s labral sheath.

Fig. 7. Ventral view of mouth parts:
B basal piece.
mds mandibles.
mx maxillæ.
P palpus.

NOTE—All drawings much enlarged; natural size of many indicated by line to the right of specimen.

PLATE V.



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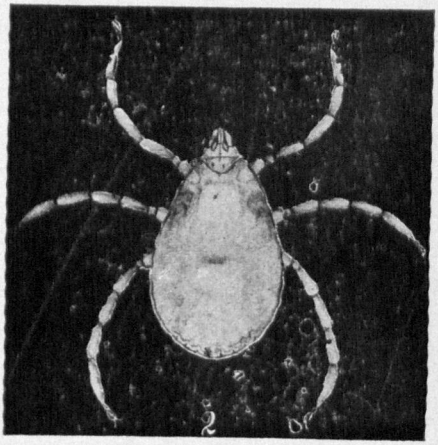

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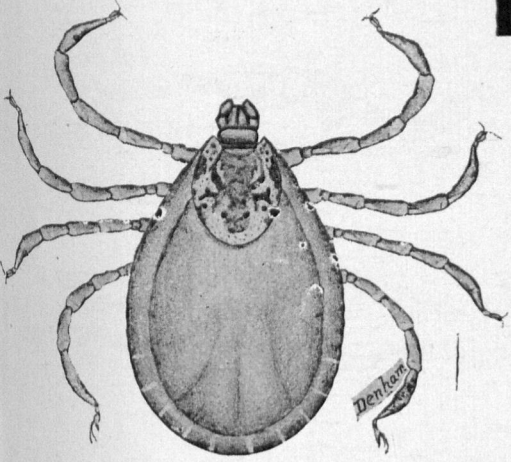

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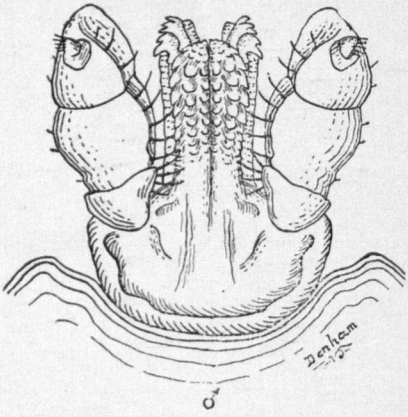

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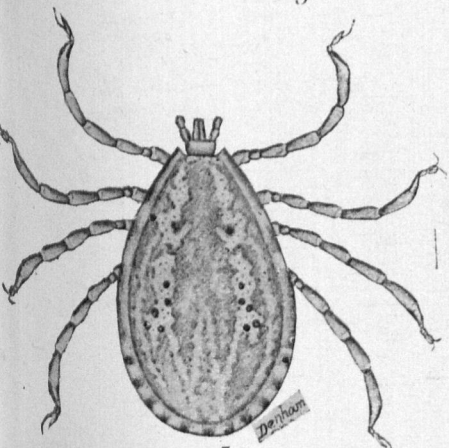

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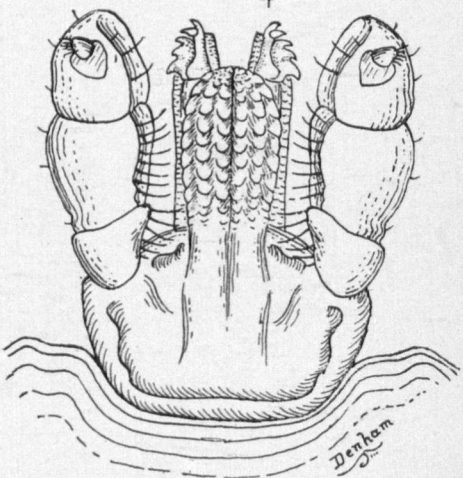

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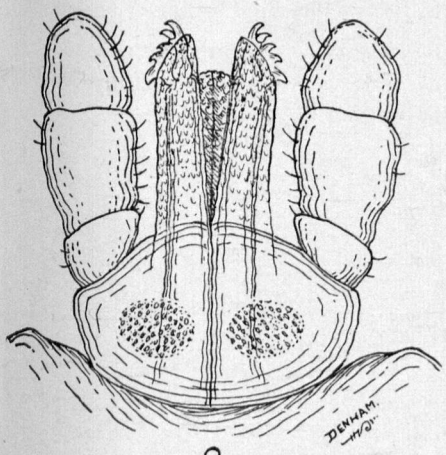

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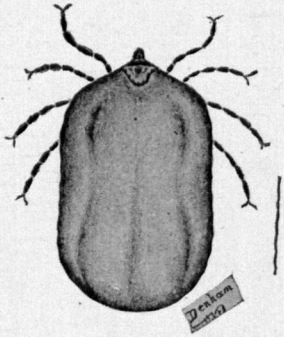

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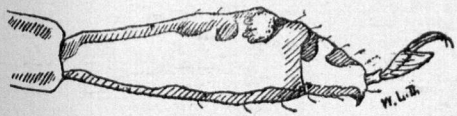

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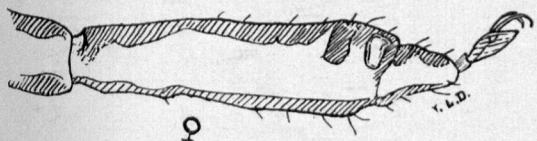

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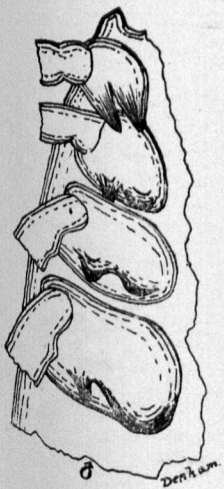

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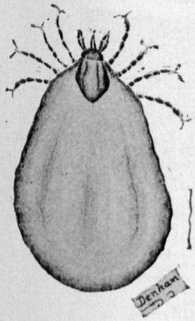
PLATE VII.



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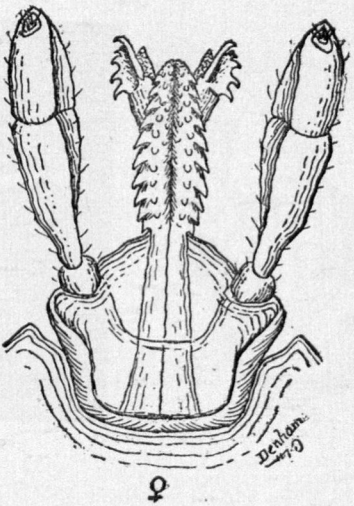

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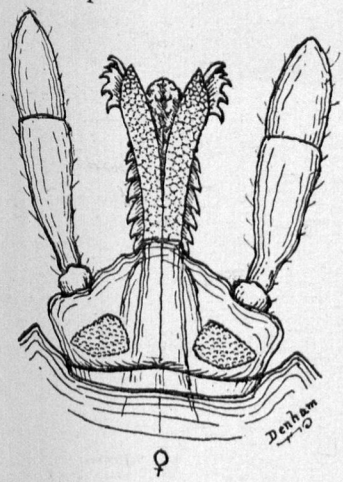

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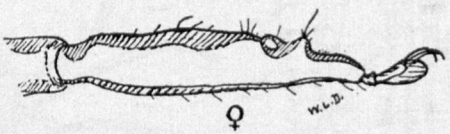

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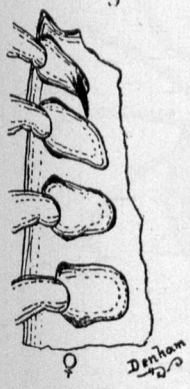

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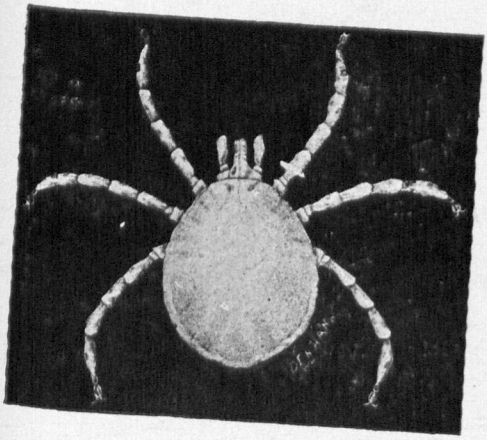

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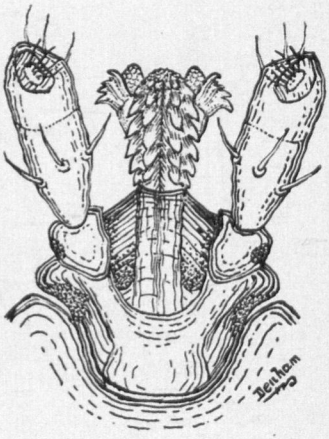

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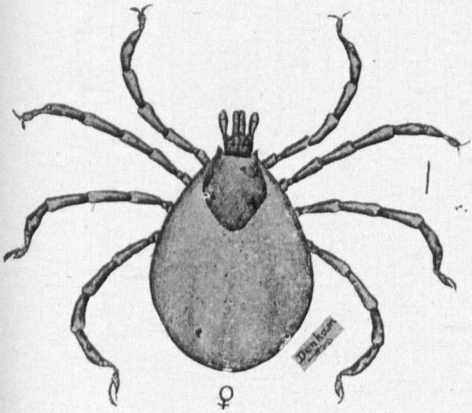

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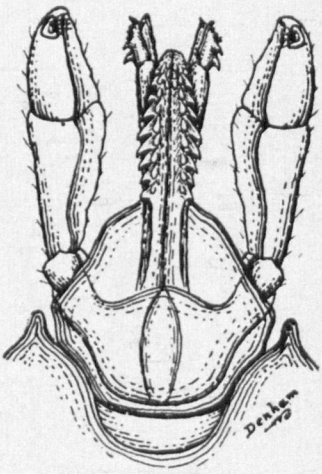

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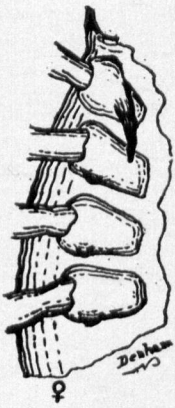
PLATE IX.



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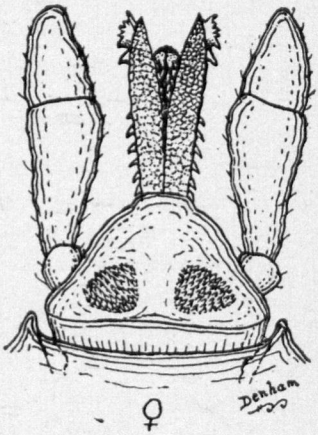

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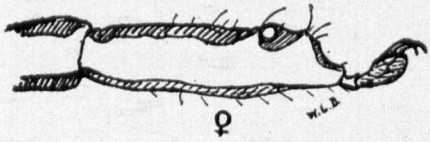

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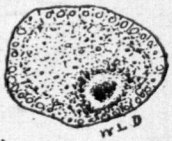

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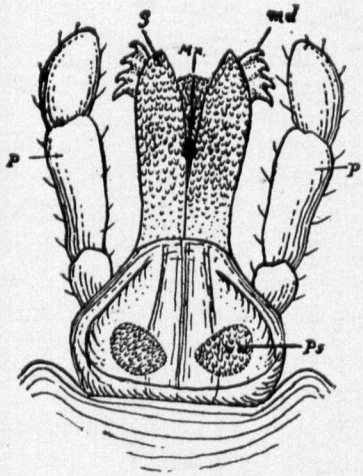

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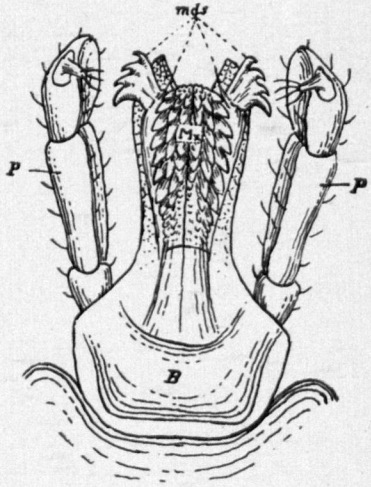

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three miles from Baton Rouge; from a dog, and from native cattle. Applications of seed ticks, the product of those collected from deer, were made July 2nd in great numbers. The seed ticks, the product of those collected from a dog, were vigorously applied to a susceptible animal on July 9, and again on August 17, while seed ticks, the young of those collected from native cattle, were applied to a susceptible animal on July 16, July 25, and again on August 9. No signs of fever appeared during all the experiments, the animals remaining in perfect condition until the test of their susceptibility was made by infesting them with the cattle tick on the 23rd of September. As the animals suffered from a vigorous attack of Texas fever after being infected with the cattle tick, we feel safe in concluding that the lone star tick does not convey the fever germ. This conclusion was fully borne out when during March, 1899, the lone star tick was collected in the third stage (just after the second molt) from native cattle, and permitted to develop upon susceptible animals. The fact that this species, dropping from native cattle and developing upon non-immunes, does not convey the fever, is important, owing to the liability of this tick to change its host during development.

EXPERIMENTS WITH THE WOOD OR DOG TICK.

On July 19, 1898, mature females of the wood or dog tick (*Dermacentor americanus*) were collected from a dog. Eggs were deposited, and on August 29th thousands of seed ticks were placed upon a susceptible animal. Another liberal application was again made on September 5th. The animal remained in good condition, showing no signs of fever until tested with an infestion of the cattle tick. No opportunity was afforded of testing this species in the third stage (previous to engorgement), as we were unable to rear it upon cattle from the first to the third stages.

CLASSIFICATION OF TICKS.

The late Dr. Marx in the proceedings of the Entomological Society of Washington, in two papers of these proceedings, one "A Note on the Classification of the *Ixodidae*" (Vol. II, No. 2, page 232), and the other "On the Morphology of

Ticks" (Vol. II, No. 3, page 271), has given us the most valuable information upon this subject.

The following is a copy of Dr. Marx's classification of the *Ixodidae* as given in the proceedings of the Entomological Society of Washington, Vol. II, No. 2:

"In regard to the systematic value of this group of Arachnida I will consider it as a suborder of the Acari, and, as Degeer, long before Koch, gave the name *Ricinus* to a genus of Pediculi, I propose for this suborder the name *Cynorhœstea*, the oldest name for ticks, since Homer said: "Enda kuon keit Argos enipleios *Cynorhœsteon*—there laid Argos, the dog, covered with Ticks."

"Aristotle and the old Greeks called the ticks 'Croton' on account of their resemblance to seeds of the castor tree, which bore the name Croton in ancient Greece. The Romans called our animal "Ricinus" for the same reason, for in their language the name of the tree was *Ricinus*, a name which is still used in the scientific botanical nomenclature. (*Ricinus communis* Linne.)

If we admit the family *Argasidæ* into the *Cynorhœstea* and hold with Koch that its natural position is here, rather than in the *Gamasidæ*, on account of the great homology of the mouth parts and other points of undoubtedly close relationship, we have to divide the suborder into two groups—the *Catastomata* and the *Antistomata*.

Suborder *Cynorhœstea*.

1. Capitulum inserted below the superior or dorsal surface, palpi not excavate at their inner side.....I. group CATASTOMATA.
2. Capitulum inserted on a level with the dorsal surface, palpi longitudinally excavate at the inner side, enclosing the sides of the rostrum.....II. group ANTISTOMATA.

Into the Catastomata I place, in addition to the family Argasidæ, with the genera Argas Latr. and Ornithodorous Koch, the family Eschatocephalidæ, based upon the genus Eschatocephalus Frauenfeld, which seems to form a connecting link between the two tribes. This, however, is provisional.

Group I—*Catastomata*.

1. Palpi considerably longer than rostrum, cylindrical, 1st palpal joint longest, 4th as long as 3d; not retractile.....family ARGASIDÆ

2. Palpi not longer than rostrum, subglobose, 1st palpal joint shortest, ring-like, 4th joint shorter than 3d; retractile.....
family ESCHATOCEPHALIDÆ
genus ESCHATOCEPHALUS Frfld

Family *Argasidæ*.

1. Capitulum hidden under a projecting, beak-like prominence, so close to the anterior margin that the tips of the palpi project from under the body and are visible from above.....
genus ORNITHODORUS C. K.

2. Capitulum at least by its length removed from the anterior margin, body without a projecting beak-like prominence in front.....
genus ARGAS Latr

Koch based the criterion of these two genera upon the presence of eyes in *Ornithodorus* and their absence in *Argas*. A close examination, however, of these two genera, which are indigenous in the United States and not uncommon in the Southern and Western States, convinced me that the presence of eyes in *Ornithodorus* is based upon an erroneous observation, and another differentiation is therefore substituted.

"Argas is so far recorded from Texas, by Prof. Packard, who described it in "Report Geol. Survey, 1873, p. 740," as *Argas americanus*.

"I have received, however, a lot from Lakeside, California, where they were found in a chicken house.

"The genus *Ornithodorus* is also found in the Southern and Western States and abundantly also in Central and South America, where it is a great pest to cattle and llamas (Brazil and Chile) and it has been found so far in the United States in Iowa, California and Arizona.

"The genus *Eschatocephalus* Frauenfeld has been found, so far, only in caves in Austria. Although the capitulum is inserted below the dorsal surface, the palpi more nearly resembles those of the Antistomata; the family Eschatocephalidæ is therefore provisionally placed in the group of Catastomata.

Group II. *Antistomata*.

"This group comprises those species which are commonly known by the name of ticks, and I divide them into three families:

1. { Front of the body, opposite the insertion of capitulum straight.....
family HÆMALASTORIDÆ
Front of body, excavate.....1

2. { Rostrum long, palpi longer than broad.....family IXODIDÆ
Rostrum short, palpi short, subtriangular, not, or only slightly longer than broad.....family RHIPISTOMIDÆ

Family *Haemalastoridae.*

This family contains the cosmopolitan genus *Haemalastor* Koch., and the European genus *Sarconyssus* Kolenati, the latter found in caves is Austria.

a. Last palpal joint longest and thickest.....genus SARCONYSSUS Kol.
b. Third palpal joint longest and thickest....genus HAEMALASTOR C. K.

Family *Ixodidae.*

1. { Body oblong oval, stigmal plate circular, peritreme round, stigma round, punctiform, maxillary armature extending down to the base of maxillæ; male without lamellæ at posterior ventral area. genus IXODES Latr.
Stigmal plate reniform, peritreme comma shaped, stigma oval....2

2. { Body nearly circular, male and female shield ornate, palpi long and slender, maxillary armature extending only half way down, male without lamellæ at the posterior ventral area..... genus AMBLYOMMA Koch
Body like Amblyomma, stigmal plate with an overlapping corner, maxillary armature extending to the base of the maxillæ, male with prominent lamellæ at the ventral area..... genus HYALOMMA Koch

The genus *Ixodes* Latr. seems to be originally a European form, since it is there represented by numerous species and appears to be in many regions the sole representative of this suborder. In the Western Hemisphere, so far as is known, it occurs only in North America, and is here represented by two species.

The genus *Amblyomma* on the contrary appears to be essentially American, and its many often brightly-colored species are found abundantly in both North and South America.

The genus *Hyalomma* inhabits principally Africa, but a species has been found on a Land-turtle in England, one from the Galapagos Islands (host unknown), and a third one upon a Land-turtle from Florida (Indian river).

Family *Rhipistomidae.*

1. { Capitulum drawn out laterally into a sharp point. Eyes present..2
Capitulum with straight sides. Eyes sometimes wanting.....3

2. { Second and third palpal joints drawn out laterally into a sharp point.....genus BOOPHILUS Curt.
Second and third palpal joints straight, not drawn out..... genus RHIPICEPHALUS Koch.

3. External border of palpi straight. Eyes present.....genus DERMACENTOR Koch
   External border of palpi drawn out into a projecting point. Eyes wanting.....4

4. External border of second joint drawn out into a sharp projecting point at the base.....genus RHIPISTOMA Koch
   External border of second joint drawn out in a more rounded form genus HÆMAPHYSALIS Koch

The new genus *Boophilus* of which the type species is *bovis* Riley* is distinguished principally by the peculiar shape of its palpi, which are very short, stand a little apart from the rostrum, and are somewhat zigzag shaped at their external border. It is very probable that *Haemaphysalis rosea* Koch, from the West India Islands, and Megnin's *Ixodes Dugesii*, from Egypt, of which I possess several males and females, belong to this new genus; as this latter species does not show any difference from *bovis* Riley it must be considered a synonym of the latter.

The genus *Rhipicephalus* is represented in North America by a beautiful species from California and one from Cape Disappointment, Washington. It seems, however, by the number of species described by Koch, to be principally an inhabitant of Africa.

Dermacentor is a common form in North America. Peter Kalm and Linneus have described it as *americanus* from the United States. It occurs everywhere, and I have specimens from Ft. Simmo, Ungava Bay, Labrador, 58° 11 L., and from Sitka, Alaska, and also from the Indian River, Florida. It is known here as the dog tick.

Rhipistoma has so far only been found on the genus Lepus, in North America. It is quite common in Kansas, Texas and California; it is also frequently met with in Austria.

Hæmaphysalis has not yet been found on the American continent; I have it from France and England.

Quite a number of other genera have been established by numerous writers: *Xypihiastor* Murray, *Cecidopus* Karsch, *Adenopleura* McAllister, *Gonixides* Duges, *Phautoixodes* Berlese, and *Gekobia* Berlese.

Some of these genera are synonyms and the others are described so vaguely that it is impossible to recognize them."

*See Prof. Gamgee's "Report on Diseases of Cattle," U. S. Department of Agriculture Special Report. 1869.

The short discussion of the more technical points used in the classification may be better understood by referring to the illustrations of the stages and the morphology of these stages in different species.

The following are among the more important points of the morphology of ticks used in this classification:

The Young—The general shape and comparative sizes of different stages, the mouth parts (capitula) of the same with special reference to the sides of the basal piece in the seed tick stadium, the arrangement and shape of the teeth as seen upon the ventral surface of the maxillæ and the distal part of the tarsus. As the tarsus changes little during the metamorphoses of ticks, it is of peculiar value in classification since other parts during engorged periods are more difficult to observe.

The Third Stadium—The most radical morphological changes excepting the presence of the stigmata, that appear after the first molt, take place between the first and second molts, and are most apparent after the second molt. The papillated spots (on females) on the dorsal surface of the basal piece of the capitulum, the increased number of rows of teeth upon the ventral surface of the maxillæ (except in *Ixodes ricinus*), the toothed condition of the labral sheath covering the mandibles, the specialization in the form of the palpi, the downward projecting of the mouth parts, the appearance of the genital opening with the specific arrangement of the tactile hairs around it, the shape of the coxæ and the form of the coxal spines, the shape and position of the dorsal shield of females, the presence of eyes, the irridescent markings of both sexes and the presence of male ventral bands, in some species, and the engorged condition of females will be found of most value in marking the last stage.

SUMMARY.

(1). A rational rotation of crops, including pasture land, will exterminate the cattle tick.

(2). The seed ticks of many species of ticks are common to pastures, especially woodland pastures.

(3). The lone star tick (*Amblyomma unipuncta*) may be bred exclusively upon cattle, but possesses the habit of dropping from the animals between molts. This species may perpetuate itself with a single brood per year.

(4). The lone star tick does not transmit the Texas fever germ, either in the seed tick condition or in other stages, even when taken from native animals and placed upon susceptible ones.

(5). The dog or wood tick (*Dermacentor americanus*) could not be developed upon cattle from the seed tick condition to the third stage, but when placed upon cattle after the second molt matures upon them. The wood or dog tick does not transmit the Texas fever germ.

(6). *Ixodes ricinus* has not been bred upon cattle, but has been found (females) upon them in the third stage, from just after the second molt on to maturity. From observations on this tick, found upon the mink, we believe this species lives continuously upon its host. We have not been able to determine that this tick does convey the Texas fever germ, though its habit of remaining continuously upon its host should be regarded with suspicion.

(7). As the life history and classification of ticks has been only partially determined, the Experiment Station is anxious to receive specimens from any portion of the tick-infected areas.

ACKNOWLEDGMENTS.

The Experiment Station wishes to acknowledge its indebtedness, in the preparation of this bulletin, to the Y. & M. V. R. R. (through the courtesy of Mr. W. D. Hurlburt, general freight agent), in extending transportation facilities which have aided greatly the investigations; to Dr. L. O. Howard, Washington, D. C., for literature references and other courtesies; to the Entomological Society of Washington, D. C., for the privilege of quoting Dr. Marx's classification of *Ixodidae;* to Mr. W. L. Denham for the drawings illustrating this bulletin, and to Mr. S. E. McClendon, who assisted materially in carrying on the work.